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FOREST PRODUCTS LABORATORY SERIES.

THE ABSORPTION OF CREOSOTE BY THE CELL WALLS OF WOOD.

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THE ABSORPTION OF CREOSOTE BY THE CELL WALLS OF WOOD.

EFFECT OF ABSORPTION BY CELL WALLS.

The location of the creosote absorbed by wood in preservative treatment has much to do with the mechanical properties of the treated material. If the cell walls do not absorb creosote, wood properly treated should not suffer a decrease in strength, provided no chemical reaction takes place. If, on the other hand, the cell walls do absorb creosote, then a weakening effect, similar to that produced by moisture in the wood, may be expected.

PAST AND PRESENT INVESTIGATIONS.

Microscopic examinations of creosoted wood made by the Forest Service in the past led to the belief that creosote did not enter the cell walls. Later experiments, however, apparently showed this supposition to be incorrect. Creosote oil, seen in a mass, appears of a dark or almost black color, but in a thin layer is transparent and almost colorless. Failure to see it in a section of wood mounted for microscopical examination, therefore, is no proof of its absence, and evidence must be sought for by other methods.

It is well known that the volume of wood varies with the amount of moisture present, increasing with the absorption of water by the cell walls, and shrinking with drying.[1] It is therefore reasonable to suppose that if creosote is absorbed by the cell walls an effect analogous to that produced by the absorption of water will occur.

Measurements[2] made at the Yale Forest School Laboratory on test specimens before and after soaking in creosote (Table 1, p. 6) indicated a slight but unmistakable swelling in the specimens thus treated. The results of another series having a similar purpose, but differing materially in the methods employed, made recently at the Forest Products Laboratory, are given in this circular.

[1] It is the water absorbed by the cell walls which causes swelling, not the free water in the cells, since after the fiber saturation point is reached water is still absorbed as free water, but no further swelling occurs. See Forest Service Circular 108, pages 8, 13 and 14.

[2] By Harry D. Tiemann, of the Forest Service.

METHODS OF TEST.

In these tests a number of pieces approximately 2 by $\frac{3}{4}$ by $\frac{1}{8}$ inch were prepared from yew (*Taxus*) and eastern hemlock (*Tsuga canadensis*). The pieces were dried in an oven at 212° F. for 24 hours, then placed in a desiccator and weighed when cold to the nearest 0.001 gram, after which they were coated with paraffin and again weighed in air and also under water.

The weight of each piece under water was corrected by subtracting the weight (under water) of the paraffin on the piece.[1] The volume of each piece was found by subtracting its weight under water (corrected) from its weight in air, the weight of the water displaced, in grams, being numerically equal to the volume in cubic centimeters.

The pieces were treated with creosote for $1\frac{1}{2}$ hours at 180° F. and 150 pounds pressure per square inch. The creosote was then heated to 220° F., and the pieces allowed to remain in it at this temperature for 5 hours, after which they were cooled in the oil. The amount of water in the creosote was not determined, but was probably less than 0.5 per cent.

When the oil had reached room temperature (about 75° F.) the pieces were removed, the surplus oil on the surface was carefully wiped off, and the pieces were again weighed in air and in water and their volumes determined as described before. The paraffin applied to the pieces before treatment was dissolved during the treatment. It was not necessary to coat the treated pieces with paraffin because the creosote made them sufficiently waterproof.

TREATMENTS WITH CREOSOTE FREE FROM WATER.

Since there was a trace of water in the creosote used, a second test was made with creosote from which the water had been removed. About 1 liter of creosote containing 0.2 per cent water was allowed to stand over 1 pound of fused calcium chloride for 24 hours. Both the creosote and calcium chloride were well shaken at intervals. At the end of this period the oil was filtered.

In this test hard maple, dried for 24 hours at 102° C., was used. The pieces, of approximately the same size as those used in the previous test, were placed in an 8-ounce bottle, *B* (fig. 1), the bottle and also the tube, *C*, being filled with the water-free creosote. A second 4-ounce bottle, *A*, was filled to a depth of one-half inch with

[1] The weight of the paraffin was determined as follows: Let P = weight in air of paraffin on piece (in grams), and p = weight under water of paraffin on piece (in grams). Then $p = P -$ weight of water displaced. Also specific gravity $= \frac{P}{\text{weight of water displaced}} = 0.89$. Or, weight of water displaced $= \frac{P}{0.89}$. Hence, $p = P - \frac{P}{0.89} = P - 1.12P = -0.12P$.

mercury. and the remaining space with water-free creosote. The glass tube, *C*, connecting the two bottles, dipped one-fourth inch beneath the surface of the mercury in the 4-ounce bottle. A second open glass tube, *D*, led from the 4-ounce bottle to the outside.

This apparatus was placed in the treating cylinder, and a pressure of 250 pounds at a temperature of from 150° F. to 200° F. was applied for 1 hour. A gradually rising temperature was maintained throughout the treatment in order to guard against outside oil being drawn into the apparatus. The mercury seal was provided as an additional precaution against anything but mercury being drawn into the 8-ounce bottle *B*. With this apparatus, the outside pressure medium might have been creosote or any other liquid, but the pieces could have been treated only with the creosote which had been placed in the bottle.

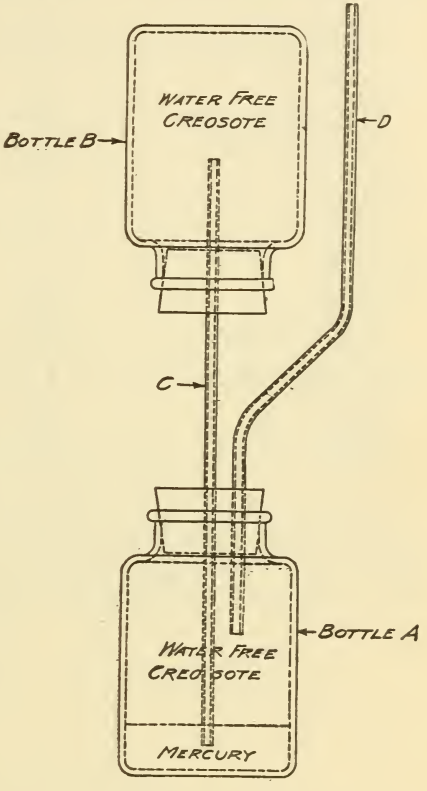

FIG. 1.—Arrangement of apparatus for treating test pieces with water-free creosote.

The volumes of the hard-maple pieces before and after treatment with the water-free creosote were determined as described for yew and hemlock.

RESULTS OF TESTS.

Table 1 gives the measurements made at the Yale Laboratory on one specimen each of spruce, chestnut, longleaf pine, loblolly pine, and white oak. Table 2 gives results of the tests on yew and hemlock, and Table 3 of those on hard maple.

The average increases in volume resulting from the treatments of the three species in per cent of the volumes before treatment were:

	Per cent.
Yew, heartwood	6.81
Yew, sapwood	10.70
Hemlock, heartwood	7.30
Hard maple, heartwood	8.14

It is thus seen that a decided swelling takes place in wood impregnated with creosote. This swelling, the tests indicate, is caused by the absorption of the creosote by the cell walls

TABLE 1.—*Swelling of wood due to absorption of creosote.*[1]

Measurements.	Species.				
	Spruce.	Chestnut.	Longleaf pine.	Loblolly pine.	White oak.
Dec. 5, 1908:					
Weight.....grams..	7.400	8.240	9.290	7.010	9.540
Radial dimension.....inches..	1.989	1.976	1.973	1.985	1.967
Tangential dimension.....do...	1.965	1.952	1.470	1.479	1.466
Dec. 7, 1908:					
Weight.....grams..	12.500	12.650	10.550	11.500	10.680
Radial dimension.....inches..	1.989	1.979	1.975	1.988	1.968
Swelling.....per cent..	0	.150	.100	.150	.050
Tangential dimension.....inches..	1.968	1.956	1.473	1.481	1.467
Swelling.....per cent..	.150	.200	.200	.140	.070
Dec. 14, 1908:					
Weight.....grams..	14.000	13.580	10.970	12.170	10.980
Radial dimension.....inches..	1.991	1.980	1.976	1.988	1.968
Swelling.....per cent..	.100	.200	.150	.150	.050
Tangential dimension.....inches..	1.968	1.956	1.473	1.481	1.469
Swelling.....per cent..	.150	.200	.200	.140	.200
Apr. 10, 1909:					
Weight.....grams..	18.800	17.400	13.900	15.200	12.750
Radial dimension.....inches..	1.993	1.991	1.995	2.002	1.995
Swelling.....per cent..	.200	.700	1.110	.860	1.420
Tangential dimension.....inches..	2.004	1.989	1.491	1.496	1.501
Swelling.....per cent..	1.980	1.900	1.430	1.160	2.390
Sept. 9, 1909:					
Weight.....grams..	18.850	17.500	14.050	15.200	13.100
Radial dimension.....inches..	2.007	1.993	2.001	2.003	1.999
Swelling.....per cent..	.900	.860	1.420	.910	1.630
Tangential dimension.....inches..	2.000	1.992	1.496	1.499	1.507
Swelling.....per cent..	1.780	2.050	1.770	1.350	2.800
Sept. 10, 1909 (after heating 100° C. five hours and cooling in vacuum):					
Weight.....grams..	19.100	17.700	14.150	15.300	13.300
Radial dimension.....inches..	2.008	1.997	2.006	2.006	2.011
Swelling.....per cent..	.950	1.060	1.670	1.060	2.240
Tangential dimension.....inches..	2.002	2.000	1.501	1.503	1.526
Swelling.....per cent..	1.880	2.460	2.110	1.620	4.100

[1] The disks measured were cut from thoroughly air-dry wood (used in preference to oven-dry wood to avoid any possible subsequent absorption of moisture from the air) and were placed in a quart preserving jar containing creosote and sealed so that no additional dampness could enter. The creosote had previously been dried, and only partially filled the jar. The disks were 0.126 inch thick when placed in the jar Dec. 5, 1908. They were kept at about 17° C. until finally heated to 100° C. for about 5 hours with the cover of the jar loose, then cooled under seal so as to be in partial vacuum.

TABLE 2.—*Weights and volumes of yew and hemlock test pieces before and after treatment.*

Species.	No.	Oven-dry weight of piece.	Weight of paraffin.	Corrected weight of piece in water.	Weight after treatment.	Absorption of creosote.	Weight in water after treatment.	Volume before treatment.	Volume after treatment.	Increase in volume.	Increase in volume.
		Grams.	*Gram.*	*Grams.*	*Grams.*	*Gram per c. c.*[1]	*Gram.*	*c. c.*	*c. c.*	*c. c.*	*Per ct.*
Yew, heart[2]	1	2.288	0.034	−1.573	5.087	0.725	0.812	3.861	4.102	0.241	6.24
	2	2.047	.055	−1.385	4.362	.733	.705	3.432	3.644	.212	6.18
	3	1.808	.044	−1.289	3.845	.657	.359	3.097	3.308	.211	6.82
	4	2.147	.064	−1.483	4.840	.742	.747	3.630	3.862	.232	6.30
	6	1.666	.108	−1.041	3.645	.732	.548	2.707	2.899	.192	7.11
	7	2.179	.084	−1.319	4.682	.715	.751	3.499	3.732	.233	6.67
	8	1.728	.101	−1.044	3.822	.755	.580	2.773	3.004	.231	8.33
Average											6.81
Yew, sap	9	.967	.063	− .749	2.405	.837	.307	1.717	1.913	.196	11.4
	10	1.140	.113	− .775	2.720	.825	.385	1.915	2.107	.192	10.0
Average											10.7
Hemlock, heart	11	1.158	.109	−1.036	2.844	.769	.273	2.194	2.357	.163	7.44
	12	1.330	.092	−1.487	3.616	.812	.344	2.817	3.009	.192	6.75
	13	1.481	.104	−1.419	3.750	.782	.302	2.901	3.130	.229	7.90
	14	1.373	.112	−1.849	4.102	.847	.284	3.223	3.452	.229	7.12
Average											7.30

[1] Based on volume of wood before treatment. [2] Piece No. 5 was lost during the tests.

TABLE 3.—*Weights and volumes of maple test pieces before and after treatment.*

Species.	No.	Oven-dry weight of piece.	Weight of paraffin.	Corrected weight of piece in water.	Weight after treatment.	Absorption of creosote.	Weight in water after treatment.	Volume before treatment.	Volume after treatment.	Increase in volume.	Increase in volume.
		Grams.	*Gram.*	*Grams.*	*Grams.*	*Gram per c. c.*[1]	*Gram.*	*c. c.*	*c. c.*	*c. c.*	*Per ct.*
Maple, heart	1	2.434	0.127	−1.112	4.095	0.456	0.148	3.646	3.947	0.301	8.26
	2	2.470	.160	−1.160	4.307	.506	.370	3.630	3.937	.307	8.46
	3	2.050	.143	− .982	3.608	.514	.291	3.032	3.317	.285	9.45
	4	2.145	.140	−1.009	3.755	.510	.338	3.154	3.417	.263	8.34
	5	2.044	.130	−1.024	3.588	.503	.279	3.068	3.309	.241	7.86
	6	2.141	.102	−1.102	3.800	.512	.324	3.243	3.476	.233	7.18
	7	2.381	.107	−1.164	4.168	.504	.336	3.545	3.832	.287	8.10
	8	2.310	.135	−1.138	4.057	.507	.350	3.448	3.707	.259	7.50
Average											8.14

[1] Based on volume of wood before treatment.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 3, 1912.*

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